

RESEARCH ARTICLE

Web Site Delays: How Tolerant are Users?*

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Abstract

Web page loading speed continues to vex users, even as broadband adoption increases. Several studies have addressed delays in the context of Web sites as well as interactive corporate systems, and have recommended a wide range of "rules of thumb." Some studies conclude that response times should be no greater than 2 seconds while other studies caution on delays of 12 seconds or more. One of the strongest conclusions was that complex tasks seemed to allow longer response times. This study examined delay times of 0, 2, 4, 6, 8, 10, and 12 seconds using 196 undergraduate students in an experiment. Randomly assigned a constant delay time, subjects were asked to complete 9 search tasks, exploring a familiar and an unfamiliar site. Plots of the dependent

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variables performance, attitudes, and behavioral intentions, along those delays, suggested the use of non-linear regression, and the explained variance was in the neighborhood of 2%, 5%, and 7%, respectively. Focusing only on the familiar site, explained variance in attitudes and behavioral intentions grew to about 16%. A sensitivity analysis implies that decreases in performance and behavioral intentions begin to flatten when the delays extend to 4 seconds or longer, and attitudes flatten when the delays extend to 8 seconds or longer. Future research should include other factors such as expectations, variability, and feedback, and other outcomes such as actual purchasing behavior, to more fully understand the effects of delays in today's Web environment.

Keywords: attitudes, delay, electronic commerce, performance, response time, satisfaction, web site design

Introduction

One of the most often-discussed complaints about the Web experience is the delay users frequently encounter while browsing. A delay occurs when a user clicks on a hyperlink and nothing seems to happen for several seconds. Several recent studies have determined that delay is one of the most important aspects of E-Commerce quality (McKinney et al., 2002; Torkzadeh & Dhillon, 2002; Turban & Gehrke, 2000), seriously interfering with a site's usability (Straub et al., 2002). An early study found that waiting time is the most objectionable deficiency of the medium (Lightner & Bose, 1996).

Contrary to expectations, faster connection technology on the Internet has not eliminated the response time problem. Additional increases in the speed of technology might have only marginal bearing on alleviating delay problems. Four years ago, Nielsen (1999b) forecasted that low-end users will have to endure unacceptable download times until 2008. Improvements have been slow due to (1) the exponential growth of the number of Web users in recent years, causing global waiting lines at popular sites, and (2) the unavailability of a low-cost solution for large numbers of Web users, tying many users to their modems for the foreseeable future.

Faster connections will not be the "silver bullet" many people expect. Delay can be caused by several factors (Nah, 2002). According to Rose et al. (2001), delays are subdivided into those related to processing and those related to bandwidth. Nielsen (1997) subdivided the causes of delay even further, into those attributable to the throughput of the server, the connection speed of the server and the user, the browser speed, and the Internet itself. Because each factor is cumulative, improving one link in the chain will not eliminate delay.

Therefore, the most aggressive improvements in bandwidth will not solve the bottleneck problem; on the contrary, the delays might worsen. An increased number of users operating at high speeds can make more page requests per unit of time, which could put a strain on servers. Web sites might need a much larger number of servers to provide adequate service. For example, with more than 10,000 servers (Searchenginewatch, 2002), Google has fast response. However, even with that extreme capacity, which cannot be duplicated by many sites, there are sometimes delays during heavy use.

Because these delays will be with us for some time, negative user reactions are a potential problem for Web site operators. Exploring the relationships between delays and performance, attitudes, and behavioral intentions of visitors will provide some useful answers to delay-related questions. How tolerant are users to delay? What is a tolerable delay? What are the effects of longer and longer delays?

This paper will explore the relationships between delay time and user performance, attitudes, and behavioral intentions. The next section explores previous literature in this area. The balance of the paper describes a laboratory study that we conducted to answer the general research questions.

Previous Literature

For many years, researchers have investigated a variety of issues related to delays and their effects on users. The Human-Computer Interaction (HCI) area has provided many studies that examine delay situations created by computer systems. With the explosion of the World Wide Web, slow computer response times suddenly became salient to the general public. Notwithstanding the numerous advantages that the Web provided to computer users, the slow speed of interaction emerged as a serious hindrance to Web usage. Nielsen's May 1999 survey of the official sites of large corporations revealed that 84% of the sites were judged too slow, the top design mistake. (Nielsen, 1999c, 1999d). Also, the Nielsen survey found that the average page download time was 19 seconds over an ISDN connection. According to the study, users are not sympathetic to waiting for Web content; slow response times lead to lower levels of trust toward the Web site owner and reliably result in a loss of traffic to the site. Indeed, research has shown that users will leave a site if page load times become too long (Rose et al., 2001).

Theoretical Foundations

The human-computer interaction literature dates back to the late 1960s, when early experiences with time-sharing computer systems included significant waits. The delays were caused by uneven system loads and varied greatly with the number of concurrent users.

One of the most widely-cited papers addressing problems with delay experienced by people working with computers was a conceptual piece by Miller (1968), which followed other related works such as Simon (1966), Newman (1966), and Sackman (1967). Miller proposed a set of guidelines with respect to maximum allowable delays that applied to various end-user tasks. He framed recommendations for human-computer interaction as analogous to a conversation between two people. Miller suggested that interactions lose their conversational nature after a maximum delay of 2 seconds, and a delay of about 0.5 seconds is the value resulting in highest conversational flow.

The recommendation to keep delays under 2 seconds has been heavily cited, and had been upheld as the "gold standard" of Web design well into the 1990s (Nielsen, 1999a). In fact, references to the 2-second rule in Web page design are so pervasive and the rule's face validity so well-established that its empirical origins are rarely questioned.

Other guidelines have emerged from laboratory experiments and field studies, and perhaps the most useful and comprehensive suggestions have emerged from the

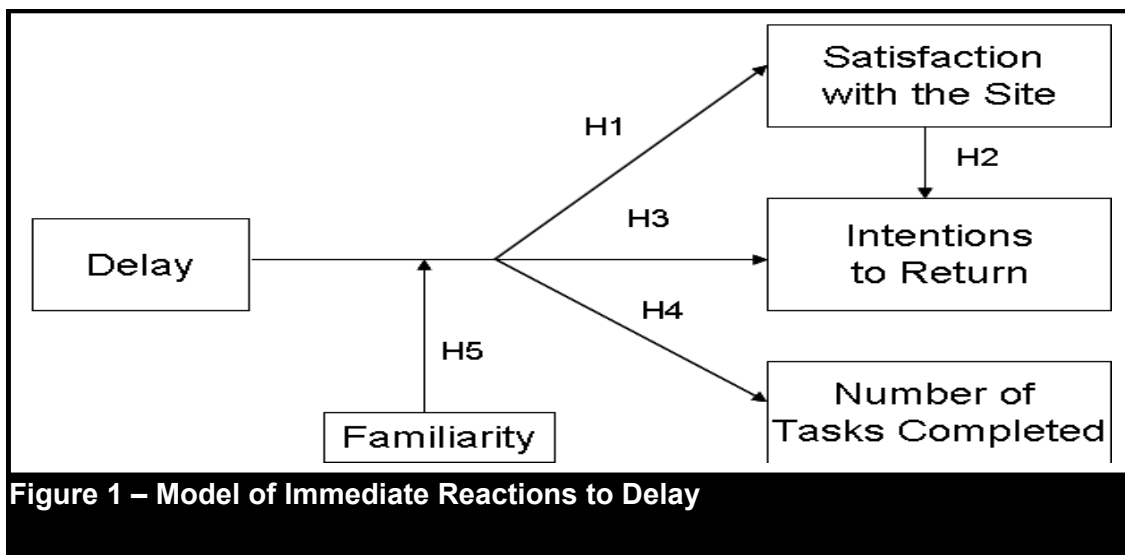
practitioner community. For example, the National Institute of Standards and Technology (NIST, 2003) recommend graphics of 30K bytes or less on a page. Also, IBM (2003) recommends that a user should gain a sense of what is contained on a page or be able to navigate off the page within 10 seconds.

In previous studies of human factors in MIS and that of Human-Computer Interaction (HCI), three important variables of interest seem to emerge. Much of the research in our field addresses three dependent variables: attitudes and/or satisfaction, behavioral intentions, and usage. The widely-cited Technology Acceptance Model (TAM; Davis et al., 1989), adapted from the Theory of Reasoned Action (see Ajzen, 2001, for a review), introduced behavioral intentions to our literature and brought sharper focus to the widespread practice of studying user attitudes. Usage has been studied for decades and can be found in perhaps dozens of models in the literature. In contrast, although there have indeed been studies of individual performance tracing all the way back to the "Minnesota Experiments" (Dickson et al., 1977), researchers in MIS have not used individual performance as one of the main dependent variables. Many choose to study technology effectiveness at higher levels of aggregation, such as the group, the IS department, the organization, or the industry.

Much of the research in the HCI literature, in contrast, addresses performance to the frequent exclusion of affective variables such as attitudes. A well-known debate in the HCI field occurred almost two decades ago, when Newell and Card (1985) asserted that hard science would crowd out soft sciences, stating that only performance studies would survive over time. Our field tends to focus more on the context of technology, so this debate has not occurred in MIS; however, performance is certainly a variable that can be quite relevant to MIS researchers.

Candidates for inclusion, therefore, include at least attitudes, behavioral intentions, usage, and performance (operationalized as satisfaction with the site, intentions to return, and number of tasks completed). In laboratory studies, it is difficult to measure actual usage in a work context, but attitudes, behavioral intentions, and performance are all outcome variables that are likely to be useful. Previous laboratory studies have suggested that these three outcomes are important (Galletta et al., 1995; Carbonell et al., 1968).

Figure 1 illustrates a model that we will investigate in this study. Note that neither TAM nor its most recent incarnation, the Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003) is used as a basis for the model. Also, we are not proposing a linear chain of linkages among the three dependent variables in our model.



There are several reasons for our approach. First, we are not studying acceptance of technology, but immediate reactions to variations in delay in a casually-used Web site. Second, this study is meant to explore the well-traveled territory of how delay affects three promising candidate variables that have been identified in a number of previous studies. We form our hypotheses from other cited studies that support direct relationships between delay and each variable. If we would instead disconnect delay from behavioral intentions and performance and form a (possibly linear) causal chain of constructs (such as delay leading to attitudes leading to behavioral intentions), we would lose the ability to investigate main effects of delay on behavioral intentions and performance.

A better understanding of users' immediate reactions could form the basis for further study of a causal chain of constructs over a longer time period. This first step explores the existence of such reactions, which fits a laboratory setting. If we find evidence for immediate reactions, those constructs can then be used in a field setting, with less control over conditions but opportunities for rich manipulation of attitudes, behavioral intentions, and performance.

The following sections describe the background of each of the dependent variables in the model and the hypotheses tested in this study.

Attitudes

Attitudes about information systems have long been studied in experiments, surveys, and field studies. Attitude measures have been used as surrogates for success at nearly all levels of granularity and have been assessed at the individual, group, and organizational levels of analysis. The word "attitude" can cover a variety of feelings, such as general satisfaction, perceptions of quality, and even emotional response.

In this study we define "attitude" as satisfaction with the site, following Au et al. (2002). Attitudes should not automatically be equated to satisfaction, although a sharp distinction cannot always be found. We might draw a useful base from dictionary definitions: "satisfaction" is usually defined as a consumer's gratification or fulfillment of a need (consistent with Oliver & Swan, 1989), and most definitions of "attitude" refer to a general disposition with many dimensions (consistent with Hilgard, 1980). That is,

satisfaction usually fits a discussion about an experienced product, while an attitude can either precede or follow that experience.

Measures of information product like a Web site do not fall into either distinction unambiguously. Web sites involve satisfaction because a user has a need that the site attempts to gratify or provide a path toward such gratification. However, the site itself is usually not the object that a merchant wishes to be consumed: it is intended to build positive attitudes and momentum toward making a purchase that will eventually satisfy the user's need.

Therefore, as Au et al. (2002) stated, we will assume that "satisfaction comprises an affective attitude towards an object." A central assumption in our research is that the amount of satisfaction a user has with the Web site's interface (an attitude) will be a dominant component of a general attitude about shopping at the site, and result in a behavioral attitude (or intention) about returning to the site. In this study, we chose to focus only on the affective attitude (satisfaction) and the intentions to return, in order to reduce any possible overlap in the outcomes studied.

The literature has provided some understanding of Web delay and attitudes. Table 1 provides a list of studies in the area of attitudes with their major findings. Each of the more detailed areas shown in the table will be covered, in turn, in the discussion below.

Table 1 – Studies of Attitudes and Web Delay

Study	Major Findings
Outcomes of Web Delay	
• Rose, 2000	Theoretical supporting mechanisms for attitudinal outcomes of delay on the Web are offered. A review of the literature shows previous findings in contexts such as computer hardware, software, restaurant service, and banking.
• Rose & Straub, 2001	Negative attitudes caused by delay do not carry over to the retailer.
• Ramsay et al., 1998	Faster pages were more interesting and easier to scan
• Hoxmeier & DiCesare, 2000	In a study of delay of 3, 6, 9, and 12 seconds, satisfaction was constant through the 9 second delay condition and dropped for the 12 second delay condition.
• Palmer, 2002	General support was found for an assertion that delay leads to lower perceived success by users (using two of three methods of measuring delay).
Estimates of Web Delay	
• Weinberg, 2000	When users expected slower response time, their estimates of actual response time were longer. Perceptions of quality were not affected by expectations.
Delay Moderated by Other Factors	
• Jacko et al., 2000	Users often attribute delay to the excessive use of graphics on Web pages. Slow sites with graphics led to perceptions of lower information quality and site organization than for text pages.
• Davis & Hantula, 2001	Academic experience moderated the effect of delay on two measures of satisfaction with on-line learning materials. Inexperienced users were not as affected by increasing delay as experienced learners.
• Galletta et al., 2003	Attitudinal effects of delay depended on a site's breadth and a user's familiarity with the site. Delay was most tolerable in broad, familiar sites.
• Polak, 2002	Attitudinal effects of delay were found to be alleviated, in part, by feedback during long delays. Variability of the delay did not seem to affect attitudes.

Outcomes of Delay

Theoretical support for examining attitudes as an outcome of delay is borrowed from the interpersonal communication literature, which in turn has been adapted by the advertising literature (Rose, 2000). Previous research shows that nonverbal cues account for a large proportion of variance in attitudes. Rose's work demonstrates that delay indeed has strong effects on attitudes. In a related study, using delays of 0, 5, and 30 seconds, Rose and Straub (2001) reported that the negative effects of delay do not affect a person's attitude toward the retailer, however, and suggest that further research is necessary.

In a study of latencies ranging from 2 seconds to 2 minutes, Ramsay et al. (1998) found that users consider faster pages more interesting than slower pages. The study also found that users believed that pages loading more quickly were easier to scan than their slower-loading counterparts.

Hoxmeier and DiCesare (2000) employed a simulated Web environment and engaged subjects in an information retrieval search task using download delays of 0, 3, 6, 9, and 12 seconds. The results supported a significant relationship between satisfaction and delay, with satisfaction being highest in the 0-second delay condition. Satisfaction remained fairly constant throughout the 3 to 9-second range, but there was a noticeable drop in the 12-second delay condition.

Palmer (2002) used a unique approach and, rather than manipulating delay with fictitious sites, measured the delay of real sites using three different techniques: a panel of judges, a rating by an outside organization (Alexa), and a software agent. He found that, in general, delay significantly affected site success.

Estimates of Delay

Weinberg (2000) studied the role of perceptions on user estimation of download time and satisfaction with a Web site by presenting Web site visitors with a message informing them about the subsequent wait. Messages in the two treatment conditions stated that the wait was either 5 or 10 seconds, but the actual wait duration was 7.5 seconds for both conditions. The results showed that users in the 5-second message condition reported significantly lower estimates of the waiting time (5.62 s) than users in the 10-second message condition (8.66 s). However, the study found no significant differences in perceived Web site quality between the treatment conditions.

Delay Moderated by Other Factors

Jacko et al. (2000) provided evidence that users attribute slow download speeds to an excessive amount of graphics on Web pages. When speeds were slow, users perceived lower information quality and lower site organization than sites with graphical pages had than sites with text pages. Apparently, users blamed the slow speed on the excessive use of graphics, which was considered to be a design choice made by the site provider. Because the design was within the provider's control, users made higher negative attributions for slow graphic sites than for slow text pages where they perceived that the designer could do little to improve the download speed. Due to the possible interaction among various design elements and download speed, it is necessary to carefully control factors that could influence users' responses to dependent measures.

The opportunity to identify interactions led us to examine attitudes in a comprehensive study of Web design factors affecting user attitudes, intentions, and performance conducted by Galletta et al. (2003). The effects of page download speed, structural depth of the Web site, and familiarity level of the Web content (described below) were varied. The delay construct assumed two values: an instant response with no delay, and a response with a delay of 8 seconds. Subjects' attitudes were more favorable with faster, broader, and more familiar sites. A 3-way interaction among the factors showed that designers can make up for long delays with a broader structure and an organization with familiar categories.

In a follow-up investigation, Polak (2002) extended the previous study by examining the effects of delay length, delay variability, and feedback given to users while waiting for page loads in a simulated Web browsing session. Polak manipulated the delay to be, on average, 2 or 10 seconds from a user's click on a link until a complete page load, with either no variability in time intervals between viewing successive Web pages (always 2 seconds or 10 seconds) or 60% variability in both directions from the respective means. A third factor was feedback (providing or withholding process feedback through partially and increasingly displaying the page content as it loaded). Attitudes were most strongly predicted by the delay itself, although providing feedback during long delays helped to alleviate the negative effects of delays to some extent.

Summary

Based on the extensive literature on the effects of delay on attitude, we propose:

Hypothesis 1: Increasing levels of delay will have negative effects on satisfaction with the Web site, but those effects will diminish with each further unit of delay.

Also, we expect attitudes to lead to behavioral intentions. Unfortunately, in newer versions of TAM, as well as its successor UTAUT (Venkatesh et al., 2003), the strong relationship between attitudes and behavioral intentions is overshadowed by other related constructs such as performance expectancy (usefulness) and effort expectancy (ease-of-use). Because our study does not involve usefulness of the site in any job situation, and we are only addressing one aspect of ease-of-use, it is appropriate to consider the satisfaction variable.

The basis for expecting attitudes (in this case, satisfaction with the site) to lead to behavioral intentions (to return to the site) in this study is found in the Theory of Planned Behavior. According to meta-analyses by Armitage and Conner (2001) and Kim and Hunter (1993), attitudes and behavioral intentions are highly related. Kim and Hunter (1993) found a correlation of .65 between attitudes and intentions, representing more than a hundred studies and a large variety of situations. Therefore,

Hypothesis 2: Satisfaction with the web site is directly related to behavioral intentions to return to the site.

Behavioral Intentions

Behavioral research, including that done in MIS, has a long tradition of measuring behavioral intentions (Ajzen, 2001). An obvious issue is the extent to which behavioral intentions are a useful reflection of subsequent behavior. In this study we are concerned with a user's intentions to return to a site if the opportunity presents itself again.

There is substantial support for considering behavioral intentions, as they have represented a pivotal construct in major models of users for decades. Behavioral intentions have been found to be a major determinant of behavior (Davis et al., 1989; Sheppard et al., 1988; Hill et al., 1987). In a meta-analysis of 86 studies, Sheppard and colleagues found an average correlation of .54 between behavioral intentions and subsequent behavior.

Research on Web site quality has been a focus of multiple academic and practitioner publications, and behavioral intentions to return to the site have been used in a Web context in previous work (Koufaris, 2002). A Web user's behavioral intentions to return to a site or recommend the site to others (Devaraj et al., 2002) can serve as an excellent summary variable that indicates content and/or design success, leading to increased popularity or revenue, or both. Even in a site that does not involve sales, increased popularity can provide justification for higher advertising rates, leading to more revenue. Several academic studies have been conducted that consider behavioral intentions as an outcome of Web delay. Table 2 provides a summary of those studies.

Table 2 – Studies of Behavioral Intentions and Web Delay

Study	Major Findings
Outcomes of Web Delay	
• Ranganathan & Ganapathy, 2002	Slower pages cause users to seek alternative sites
• Galletta et al., 2003	Behavioral intentions were more favorable with sites that were faster, broader, and those having a more familiar structure.
• Hoxmeier & DiCesare, 2002	Intentions to revisit a site decreased significantly as delays increased from 9 to 12 seconds.
• Rose et al., 2001	Users showed a predisposition to abort loading of an e-retailer's Web page as delays extended.

In general, the findings on behavioral intentions and Web delay are similar to those on attitudes. Slow response time can frustrate consumers, causing them to seek alternative sites (Ranganathan & Ganapathy, 2002). Galletta et al. (2003) found in their study of speed, familiarity, and depth that subjects' intentions were more favorable with faster, broader, and more familiar sites. Hoxmeier and DiCesare's (2000) study of the effects of 0, 3, 6, 9, and 12 second delays revealed that intentions of system reuse decreased significantly in the 12-second category. Rose et al. (2001) studied Web page delays of 0, 15, 30, 45, 60, and 75 seconds, and found that delay had a significant impact on users' intentions to abort loading of an e-retailer Web page.

Summary

Based on the literature on the effects of delay on behavioral intentions, we propose:

Hypothesis 3: Increasing levels of delay will have negative effects on intentions to return to the Web site, but those effects will diminish with each further unit of delay.

Performance

The HCI literature has focused substantial attention on performance as "the" central dependent variable for users of technology. Accordingly, system design factors in both hardware and software arenas have been assessed with user-system performance as

the “ultimate concern” (Card et al., 1983, p. 404). Performance has been studied for decades, predating the World Wide Web. Table 3 provides a summary of studies relevant to delay and performance.

The table provides general studies; we have not found many studies that address Web delay and user performance besides the one by Nah (2003). It is striking that, perhaps because of our heritage, studies in MIS about Web delay most often include only attitudes and/or behavioral intentions, while, perhaps because of the HCI research tradition, nearly all pre-Web published studies of delay address only user performance.

Table 3 – Studies of Performance and Delay

Study	Major Findings
Pre-Web Performance Outcomes of Delay	
• Yntema, 1968	As delays increased, users became more efficient, using fewer steps to solve a problem.
• Goodman & Spence, 1978	Time to solution increased by 50% when system response time doubled.
• Thadhani, 1981	User productivity and user response time improved by faster system responses.
• Bergman et al., 1981	Faster system response time led to less efficient strategies
• Butler, 1983	Faster system response time did not affect typing time or correctness of entries for either a simple or more complex task. Faster system response time led to faster user response time only for the simple task.
• Dannenbring, 1984	Faster system response time led users to commit more errors.
Web Delays and Performance Outcomes	
• Galletta, et al., 2003	Subjects were able to complete more tasks when delays were short, the site was constructed using familiar terminology, and the site was broad rather than deep. All three factors interacted (both 2-way and 3-way interactions were significant). Performance outcomes were stronger than outcomes of attitudes or behavioral intentions.
• Davis & Hantula, 2001	In one of three lessons on a training site with text showing up immediately and graphics loading over 2 to 32 seconds, delay had a non-linear <i>facilitating</i> impact on learning performance; delay gave academically-inexperienced subjects more time to read text while graphics loaded. Other lessons had mixed results.
• Polak, 2002	Delays predicted user performance more strongly than page loading feedback or variability in loading speed.
• Nah, 2003	Subjects waited a very long time before aborting the task only for the first non-loading link. Subsequent wait times were about a fifth as long.

Pre-Web Performance Outcomes and Delay

HCI research commenced with studies of user strategies in problem solving situations and user adaptation to various delay conditions. Results reported by Yntema (1968) showed that as users worked with longer delays, their work strategies indeed changed to accommodate the response characteristics of the system. Users took more total time to solve the problem, but they achieved a solution in fewer steps. As the interactions with the system became more costly in terms of time, the users became more careful with system usage and used fewer computer resources.

A study by Goodman and Spence (1978) investigated the effects of increasing system response time (SRT) on users' performance and found that time to solution increased by 50% when the SRT doubled from 0.7 seconds to 1.5 seconds. A further increase of SRT to 3.2 seconds resulted in a decrease in users' performance by an additional 50%, and caused users to complain about the intrusive nature of the system's operation.

In an empirical investigation of user productivity, Thadhani (1981) found a significant correlation between performance variables and system delay. The data showed that user productivity was significantly higher in the 0.25-second to 1.0 second response range than in the response range greater than 1.0 second.

However, Bergman et al. (1981) reported results that were different from those obtained in previous studies. The authors experimented with system response times of 0 and 10 seconds and the results showed no positive effects of short delay on performance measures that were similar to those used in prior research. Total time and total number of trials to reach a solution, total response time and per trial user response time, and number of trials per minute were among the performance characteristics studied. The data showed that users needed more trials to solve a problem in the immediate response condition than in the 10-second delay condition, which supported Yntema's (1968) observation that users adapt their strategy when delays become costly. That is, as delays become longer, users reduce the number of steps taken.

Butler (1983) conducted two experiments with experienced users performing tasks on cognitively different levels. One task involved simple data entry, and the other was a more demanding information retrieval and record modification task. System response time under investigation assumed a wide range of possible values: 2, 4, 8, 16, and 32 seconds. Again, performance variables served as dependent measures and consisted of typing time, the percentage of incorrect entries, and user response time. Butler's analysis indicated that the amount of delay did not significantly affect the mean typing time or the percentage of incorrect entries. The only observed relationship was between delay and user response time in the data entry task. Butler concluded that "the degradation in user performance seen when average response time is increased appears to be very similar for tasks that are cognitively very different" (p.62). This finding seems to remain uncontested, as we could find no other experiment with cognitively different levels of experimental task measured at various response times.

Dannenbring (1984) conducted an experiment in which beginners and experienced programmers alike were engaged in a quite complex task of debugging a short computer program. User performance and user satisfaction were studied under conditions of 0-second, 5-second, and 10-second system delays, and instructions to work as quickly as possible. The only performance variable found significantly related to system delay was the number of corrections of erroneous entries, with fewer characters or lines deleted as delay increased. The findings suggested that faster system response times cause the subjects to make more errors, a result consistent with Bergman et al. (1981). Interestingly, user satisfaction with the system, perceived difficulty of the task at hand, total time to solution, and other performance measures failed to show a general relationship with computer response time.

It might be unexpected to observe a greater number of errors when response time is fast, but Wickelgren (1977) offered a possible explanation: when response time decreases, users tend to work more quickly, as if they are trying to keep up with the

system. In doing so they comprehend less and make more errors in both planning and execution. In short, the system might make them feel the need to rush.

Web Delays and Performance Outcomes

Performance was another dependent variable in the study by Galletta et al. (2003) discussed above. Subjects were able to complete more tasks with faster, broader, and more familiar sites. In addition, of all of the dependent variables, performance measures were influenced most strongly by interactions among the factors. Performance was significantly affected by all of the two- and three-way interactions between site depth, familiarity, and speed.

In an investigation by Polak (2002), where delay length, delay variability, and feedback given were manipulated, the delay was the most significant predictor of performance on a search task. Although providing feedback (gradually loading graphics) to subjects during long delays helped to alleviate the negative effects of delays to some extent, the absolute length of delay was critical to the users' performance.

Another feedback study was performed by Nah (2003). In this creative study, subjects were provided with ten links, and only seven worked. Subjects who were provided feedback (a status bar) waited on average 38 seconds after clicking on the first non-working link before giving up, while those without feedback waited only 13 seconds. In subsequent attempts, the subjects waited only 3 seconds without feedback and 7 seconds with feedback. Patience, therefore, does not seem to last forever.

Summary

Based on previous studies of the effects of delay on performance, we propose:

Hypothesis 4: Increasing levels of delay will have negative effects on performance on browsing tasks, but those effects will diminish with each further unit of delay.

Familiarity

Consideration of other factors that moderate the relationship between page loading delay and attitudes might provide substantial enlightenment in understanding delay. In this study, we will make use of one of the moderating variables from Galletta et al. (2003), familiarity.

The construct of "familiarity" was intended to take into account the rich literature of HCI in the area of menu design, on the composition of a system into menus and sub-menus. Studies by Liebelt et al. (1982) and McDonald et al. (1983) state that designs must employ meaningful categorization. This is perhaps an obvious conclusion; however, the categorizations need to be familiar to users. Stated another way, when groupings are unfamiliar to users, the categorizations lose their meaning (Robertson et al., 1981; Norman & Chin, 1988).

For example, it would be easy and natural for many in the MIS field to find computer memory in the category "Dynamic RAM" and to find a CompactFlash card in the category "Static RAM," but for a novice, the very clear cues seem random and non-meaningful. In another illustration, a physical therapy patient, researching a prescription for treatment with an ultrasound machine would need to look under "Modalities" as a category, while massage would be found under "Procedures." Without knowing that

procedures are largely manual and modalities use heat, cold, sound, or light, a patient would become lost almost immediately while trying to navigate such a list to gain more information.

Because navigating a Web site that is organized from general to specific elements is much like choosing items in a menu, it is important to ensure that users are familiar with the categories that decompose the information into pages and sub-pages. Failure to use familiar terminology violates all three of the ease of use guidelines from Microsoft (Keeker, 1997), adopted by Agarwal and Venkatesh (2002): having clear and understandable objectives, being organized appropriately, and being able to know when you are getting closer to your goal. Although we would not expect a designer to structure a site completely randomly, it would appear so to a user who is unfamiliar with the terminology.

Therefore, we will use the term “familiar site” to represent a site that is structured using terminology that is known to the user. In contrast, an “unfamiliar site” represents a site that might be decomposed in a very meaningful way to an expert, but provides no meaningful cues to its navigation to a novice.

An unfamiliar site will force a user to examine more pages, and therefore might emphasize the effects of delay. Therefore, we hypothesize that the effects of delay are different for sites that require different amounts of interaction, and propose the following interaction hypothesis:

Hypothesis 5: Familiarity will moderate the relationships between delay and all of the outcome variables.

Overall Summary

Issues related to delays on the Web have recently attracted the attention of researchers. Laboratory experimentation appears to be the primary method of investigation, as it enables strong control over the environmental settings. The results indicate that users prefer Web sites with short delays over sites with long delays, as one might expect. Also, fast sites seem to encourage exploration and decrease the penalty for making errors.

Although these findings are quite consistent across different studies, there is neither comparability among the findings nor data available representing close enough intervals to formulate a curve of a user’s tolerance for delay across the intervals. Also, each previous study included a limited variety of variables, so it is difficult to tie performance, attitudes, and behavioral intentions to specific levels of delay.

This study, therefore, examines the effects of increasing delay on user performance, attitudes, and behavior intentions, using a laboratory experiment.

Method

We manipulated speed by using a Javascript program on each page to provide a randomly-assigned constant delay of 0, 2, 4, 6, 8, 10, or 12-seconds per page. Considering a delay “long” is quite subjective and it was therefore difficult to make the

choice given the wide range used in previous experiments. We wanted to have enough settings to include at least two values above a commonly-discussed maximum of eight seconds (Hoxmeier & DiCesare, 2000; Ramsay et al., 1998; Zona, 1999; Shneiderman, 1998; Kuhmann, 1989). Also, our simple site did not seem to contain enough graphical content to justify a longer delay, which could lead to unpredictable attributions (Sears & Jacko, 2000).

We imposed the same delay over each particular site, although Rose et al. (1999) noted that user response to delay intervals during an initial visit to a site can differ from delay with each subsequent page request within the same site. We focused only on page loads within a site and did not wish to provide any potential confusion, complexity, or confounds that might be caused by using differential delay for the initial site access.

Materials

We adopted two artificial Web sites from a previous study (Galletta et al., 2003), and included "Pete's General Store" as the "familiar" site and "A.C.T. Systems" as the "unfamiliar" site. The familiar site contained groceries and/or home products, arranged in easily recognizable categories such as "Health Care Products" and "Food Products." On the other hand, the unfamiliar site contained fictitious products arranged into categories that provided no clue as to their meaning, such as "Novo Products," and included completely fictitious software products and computer accessories. Both sites included brief product descriptions, prices, and images, and the search tasks led to pages in precisely the same position on each site to provide at least some measure of comparable difficulty in the two sites.

We asked users to search in both sites. To prevent confounding order effects, for half the subjects, we presented the familiar site first and for the other half, we presented the unfamiliar site first. We performed analysis of the performance means to investigate whether subjects browsing the second site had benefited from their previous browsing through the first site. One way to determine this was to compare the performance means from the identical site in each position; for example, when the familiar site was the first one, it would be important to make sure the means were not different when the familiar site was the second one.

Analysis of all sites revealed no learning effect overall. The means in Table 4 illustrate that there are no differences when comparing the performance overall (6.67 versus 6.62), or when looking at the individual treatments. The scores of subjects encountering the unfamiliar site in the first position do not differ from the scores of subjects encountering the unfamiliar site in the second position (4.57 versus 4.60) and, likewise, the familiar site scores when in the first position do not differ from those scores when it was in the second position (8.78 versus 8.64).

Table 4 – Examination of Potential Learning Effect (Performance Scores)

	First Site	Second Site	Comparison
Overall	6.67	6.62	$F(1,390)=.03, p=.86$
Unfamiliar only	4.57	4.60	$F(1,194)=.01, p=.94$
Familiar only	8.78	8.64	$F(1,194)=.953, p=.33$

Subjects

A total of 196 subjects volunteered to participate in the study, solicited from a population of upper-level undergraduate business students at a large university in the northeast United States. All of the participating faculty members offered students extra credit for participating.

We considered students to be appropriate subjects for this study because the experimental task does not focus on contextual factors and decision-making situations, and we expect most people to react in a similar way to increases in Web delays. That is, we focused on what we would expect to be “invariant” (Simon, 1990) across individuals—the hypothesized curvilinear, diminishing effects, relationship between delay and the variables of interest. Further, Voich (1995) found values and beliefs of students to be representative of individuals in a variety of occupations.

Measures

We measured **performance** by totaling subjects' scores on nine search tasks that we constructed to force users to browse the site. They were to find details contained on the lowest-level pages. For instance, some questions addressed packaging options, shipping options, or pricing of items in the on-line store.

Subjects earned one point per correct fill-in-the-blank answer, resulting in a possible score from 0 to 9. Short, dichotomous instruments are not normally subjected to reliability analysis, and reliability expectations are usually not optimistic in those cases (Nunnally, 1978). Fortunately, the Kuder-Richardson-20 statistic, or KR-20 test (analogous to alpha for dichotomous items), was quite high in this study (.90). We used SPSS version 11 for this test, as well as all other statistical tests in this paper. See the Appendix for a copy of all tasks and measures.

We measured **attitudes** about the sites by summing the responses from seven 9-point Likert-type questions adapted from Part 3 of the long form of the QUIS (Questionnaire for User Interaction Satisfaction) (Shneiderman, 1998, p. 136), which has been tested for reliability and validity in previous research (Chin et al., 1988). Cronbach's alpha was .86. We measured **behavioral intentions** using the sum of two related, original 7-point Likert-type questions: how readily the subject would visit the site again and how likely he or she would recommend that others visit the site. Devaraj et al. (2002) asked a similar pair of questions of users. The alpha score for this very short instrument was also extremely high, at .94.

We included **manipulation check items** to ensure that the experimental conditions were not too subtle for the subjects. The mean of the familiarity manipulation check was 1.98 for the subjects in the unfamiliar condition and 5.67 for the subjects in the familiar condition on a scale from 1 to 7. The difference was significant ($F(1,387)=871.3$, $p=0$). We ran a regression for delay with the number of seconds delay as the independent variable and the manipulation check as the dependent variable. The regression demonstrated that the delay was a significant predictor of the manipulation check responses ($F(1,387)=398.4$, $p=0$; adjusted $R^2=.506$).

Finally, we performed factor analysis on all measures of dependent variables. Entered variables included nine measures of performance, seven measures of attitudes, and two

measures of behavioral intentions. Principal components factor analysis with varimax rotation revealed two well-defined factors. All of the performance measures loaded clearly on one factor, and all attitude and intentions measures loaded on the second factor. No items significantly cross-loaded, and no items dropped out. Table 5 illustrates the factor analysis results.

Table 5 – Rotated Component Matrix for all Dependent Measures (Principal Components Analysis, Varimax Rotation)

Item	Component	
	1	2
Attitude1	.867	.335
Attitude2	.835	.326
Attitude3	.831	.161
Attitude4	.703	.467
Attitude5	.806	.270
Attitude6	.785	.229
Attitude7	.769	.382
Behavioral Intentions1	.876	.177
Behavioral Intentions2	.851	.113
Task1	.167	.771
Task2	.174	.678
Task3	.217	.813
Task4	.133	.704
Task5	.368	.633
Task6	.215	.748
Task7	.200	.721
Task8	.262	.615
Task9	.289	.734

Attitude and intentions measures loaded on one factor, indicating poor discriminant validity of the constructs. The measurement of intentions and attitudes in the same model has been discussed in several TAM studies (Venkatesh et al., 2003) and it is possible that attitudes actually *include* intentions. The commonly-held tripartite definition of attitudes (Hilgard, 1980) indicates that there are affective, cognitive, and conative (behavioral) components of attitudes. Perhaps the entire notion of “attitudes” needs to be revisited, or perhaps the support for H4 is simply overwhelmingly strong ($r=.8$).

Procedure

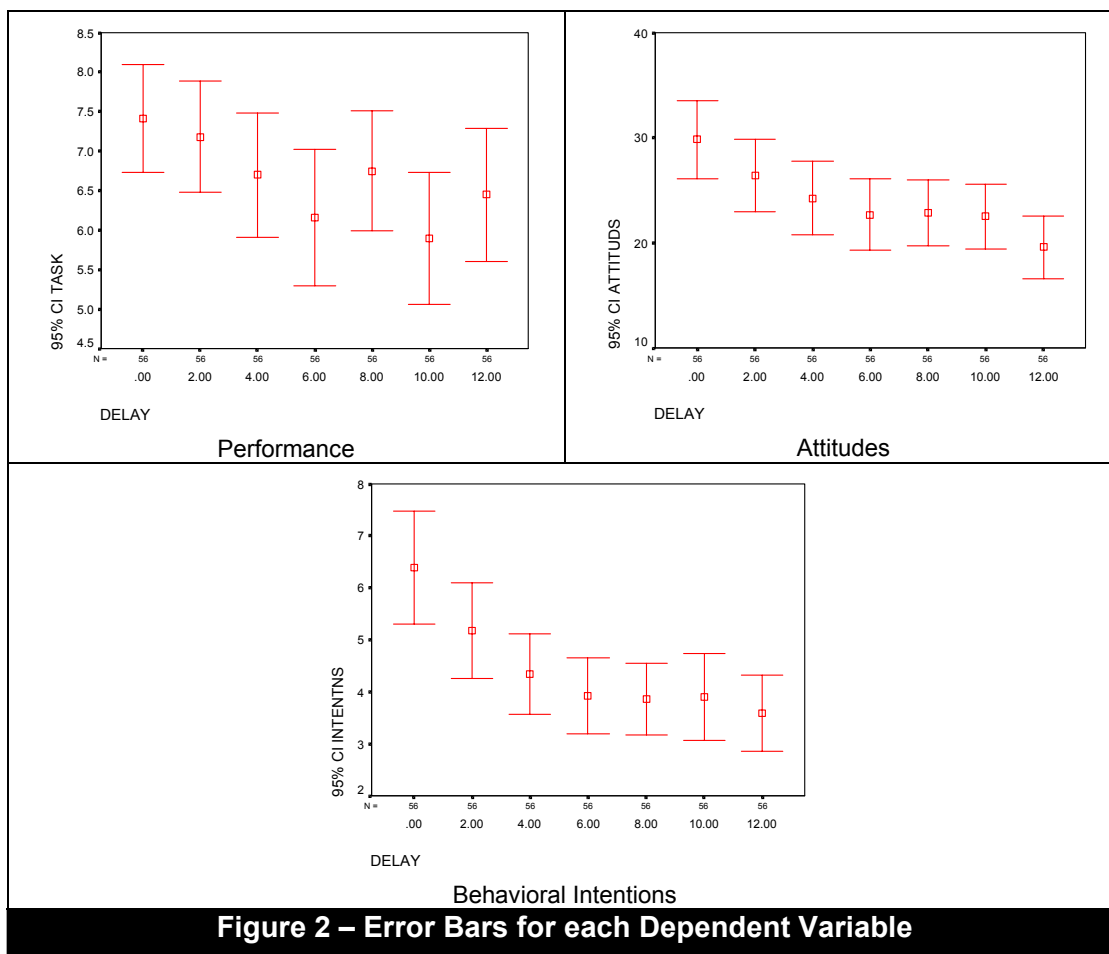
We placed the practice Web site, and the two main Web sites (familiar and unfamiliar), on CDs to precisely control the browser’s response time. All subjects used identical PCs and 17” XGA screens in a campus lab containing 46 machines. After signing an “informed consent” form, subjects were told that participation was voluntary and that they could leave the study at any time. A randomly-assigned code found on their packet was entered on the screen, activating the proper delay treatment. The experimenters ascertained that each subject entered the correct number from the packet.

The practice site provided a chance for subjects to become familiar with the search task so that they would not need to spend time learning how to answer the questions in the first experimental condition they encountered. They then undertook 9 tasks at each main site. After completing as many tasks as they could, subjects were instructed to close the

browser window and complete the questions addressing attitudes and behavioral intentions. The entire exercise took an hour to complete (on average).

Results

In graphical form, we show the basic results in Figure 2 as error bars defining means and 95% confidence intervals at each time setting. In general, the results illustrate declining performance, attitudes, and behavioral intentions as delays increased, as expected. One exception is that there appear to be performance increases at the 8- and 12- second levels. This result could indicate changes in strategies, found in other studies (Yntema, 1968), although there is not sufficient evidence to strongly support this assertion.



Our three main hypotheses (H1, H3, and H4) predicted that the effects of delay would decrease over time, which would predict curvilinear relationships between delay and its outcomes, asymptotic to the X axis. We performed two types of tests to determine if the relationships are indeed curvilinear.

First, we performed curvilinear regression and compared the results to the results of linear regression. After extensive testing using a variety of functions, a logarithmic

function always provided nearly the best fit. Although log functions would cross the X axis at very large values of delay, they are a close enough approximation to asymptotic curves at the levels we examined.

We show the results of regression testing in Table 6. The curvilinear regressions explain slightly more variance than the linear approach. The logarithmic and linear regression equations are significant for all of the dependent variables, but the amount of explained variance is relatively modest (explained variance figures for performance, attitudes, and behavioral intentions are 1.9%, 5.2%, and 7.9%, respectively).

Table 6 – Regression Results – All Subjects

Dependent	Method	R ²	d.f.	F	Sig.	b ₀	b ₁
Performance	Logarithmic	0.019	390	7.36	0.007	7.0908	-0.3213
Performance	Linear	0.017	390	6.84	0.009	7.2518	-0.0966
Attitudes	Logarithmic	0.052	390	21.37	0	27.2138	-2.3246
Attitudes	Linear	0.050	390	20.67	0	28.4685	-0.7133
Intentions	Logarithmic	0.079	390	33.67	0	5.4628	-0.7300
Intentions	Linear	0.064	390	26.63	0	5.7321	-0.2041

Because the unfamiliar site involves much more browsing than the familiar site, and is hypothesized to behave somewhat differently (H5), we performed separate analyses of each site. Analysis of the unfamiliar site revealed that the explained variance in performance and significance of the regression equations improves dramatically. Regressions for attitudes and behavioral intentions remain highly significant, but less variance is explained than was seen in pooled analysis. However, the separate unfamiliar-only analysis of attitudes and behavioral intentions resulted in equations that explain substantially less variance. As is shown in Table 7, 6.1% of the variance in task performance is explained in the curvilinear regression for the unfamiliar site only (5.3% in the linear regression), which is about three times the corresponding value in Table 6 for all subjects.

Table 7 – Regression Results – Unfamiliar Site Only

Dependent	Method	R ²	d.f.	F	Sig.	b ₀	b ₁
Performance	Logarithmic	0.061	194	12.71	0	5.3582	-0.5598
Performance	Linear	0.053	194	10.76	0.001	5.5952	-0.1614
Attitudes	Logarithmic	0.058	194	11.88	0.001	16.8726	-1.4032
Attitudes	Linear	0.037	194	7.39	0.007	17.1191	-0.3489
Intentions	Logarithmic	0.050	194	10.27	0.002	3.0935	-0.2900
Intentions	Linear	0.029	194	5.72	0.018	3.1204	-0.0682

For the sake of completeness, we also analyzed the familiar site in this manner. When data from only the familiar site are used, regressions for attitudes and behavioral intentions again remain highly significant, but performance loses significance. Curvilinear equations for attitudes and behavioral intentions explain substantially more variance (15.5% and 17.7%, respectively) in this sub-sample than in the overall sample or in the unfamiliar data only, as shown in Table 8. Because of the differences between familiar and unfamiliar sites, H5 appears to be supported strongly.

Table 8 – Regression Results – Familiar Site Only

Dependent	Method	R ²	d.f.	F	Sig.	b ₀	b ₁
Performance	Logarithmic	0.012	194	2.33	0.129	8.8233	-0.0828
Performance	Linear	0.018	194	3.57	0.060	8.9085	-0.0319
Attitudes	Logarithmic	0.155	194	35.54	0	37.5551	-3.2460
Attitudes	Linear	0.176	194	41.34	0	39.8179	-1.0778
Intentions	Logarithmic	0.177	194	41.67	0	7.8320	-1.1701
Intentions	Linear	0.154	194	35.20	0	8.3439	-0.3399

Sensitivity Analysis

One of our research goals was to learn at which point delays cease to have an effect on the dependent variables. Thus, we ran another round of regression analysis for both familiar and unfamiliar cases. This time, however, we repeatedly ran regressions after removing data from the lowest remaining time delay. That is, after running a regression for the full set of time delay categories, we removed subjects at the zero-delay level. Then, after running that regression, we removed subjects at the two-second delay. Each iteration removed the lowest remaining category. While eventually this approach would run out of statistical power, we followed this procedure simply as an exploratory step. Further research is needed to provide additional understanding of the nature of the curve as delays become quite lengthy.

After removing the zero-delay subjects, regressions were no longer significant for performance, but remained significant for attitudes and behavioral intentions ($p < .005$). Explained variance was, coincidentally, 2.4% for both measures. After the next step, removing the 2-second subjects, no regressions were significant. Therefore, across both familiar and unfamiliar sites, one might argue that any delay above 2 seconds ceases to be detrimental, and the outcomes have “bottomed out.”

The iterative analysis was repeated for the separate sites. For the unfamiliar site, only performance survives the loss of the zero-delay subjects. More specifically, the linear regression ceases to be significant, but the curvilinear regression remains significant ($p < .023$) and explains 3.1% of the variation in performance. Therefore, users in an unfamiliar site have significant reductions in attitudes and behavioral intentions with any delay at all, and suffer performance degradation when exceeding 2 seconds in delay.

For the familiar site, where only attitudes and behavioral intentions are significant to start, dropping the zero-delay subjects results in regressions that continue to be significant and explain variance. Total delay from 2 seconds and above explains 10.6% of the variance in attitudes ($p < .001$) and 6.8% of the variance in intentions ($p < .001$) in the linear regressions. Results were similar for curvilinear regressions, so only the linear results will be discussed.

After dropping the 2-second delay subjects, only the attitude data provided a significant regression equation. Linear and non-linear regression results were nearly identical. Delays from 4 to 12 seconds explained 6.4% of the variance in attitudes ($p = .003$). After dropping the 4-second delay subjects, the attitude regressions remained significant. Total delay from 6 seconds and above explained 3.7% of the variance in attitudes ($p = .041$). No further regressions were significant.

We provide a summary of the results of this Sensitivity Analysis in Table 9. The analysis shows that the regressions lost significance suddenly, and performance and behavioral intentions clearly flattened out before the loss of statistical power took over. On the other hand, attitudes showed the clearest persistence of an effect as delays lengthened, but only for the familiar site. In the unfamiliar site, attitudes were slightly more persistent in exhibiting continued decreases beyond the 2-second point, again before the loss of statistical power would have predicted.

On the basis of the analysis, it might be concluded that Web designers could “lose” their audience at much lower delays than they might expect; users might be unable to complete their tasks and they might not return if delays reach 4 seconds or more. That is, the “damage is done” at relatively low delay times for task performance and behavioral intentions. After the delay reaches 4 seconds, additional delay increases do not further degrade those outcomes. Attitudes, however, continue to degrade until they reach 4 seconds for both sites, and 8 seconds for familiar sites, where they appear to level off or until statistical power is significantly impaired.

Table 9 – Sensitivity Analysis (For each subset of time delays, this table shows for which tasks a significant regression equation could be found)

	0 & up	2 & up	4 & up	6 & up	8 & up	10 & 12
Performance	Both	Unfamiliar Only *				
Attitudes	Both	Both	Familiar Only	Familiar Only		
Behavioral Intentions	Both	Both				

* curvilinear regression results only

It should be noted that this study does not cover delays between the boundary conditions chosen. For example, it is impossible to state at what point between 2 seconds and 4 seconds behavioral intentions bottom out. Nevertheless, it provides general guidance for what might be expected with a span of possible delays. Although it would be tempting to state that additional research would be needed to determine a more precise break point, there should also be research into other types of situations or contexts that would tend to shift the curves up and down.

Discussion, Conclusions, and Limitations

This study examined how increases in delay affect Web users. The results indicate that increases in delay clearly relate to decreases in performance, attitudes, and behavioral intentions, and attitudes do predict behavioral intentions (see Table 10). All five Hypotheses were supported. These decreases are predicted more accurately by non-linear, diminishing-returns curves, as can be seen from the higher explained variance resulting from the nonlinear regression under several of the conditions tested.

Table 10 – Results of Hypothesis Testing

Hypothesis	Results
H1: Delay impairs attitudes with diminishing returns	Supported
H2: Attitudes predict behavioral intentions	Supported
H3: Delay impairs behavioral intentions with diminishing returns	Supported
H4: Delay impairs task performance with diminishing returns	Supported
H5: Familiarity moderates the relationships above	Supported

For researchers, one of this study's most important findings is that relatively small increases in delay can have a profound impact on how users react to Web sites. In this study, delays ranged from 0-12 seconds, and we found significant results at the short side of this range. Other studies investigating the effect of speed on users' reactions to Web sites have used delays as high as 2 minutes. These results suggest that it is unnecessary to impose such long delays on experimental subjects; users are much more sensitive to delay than would be apparent by examining the ranges used in the previous literature.

For practitioners, these results also suggest that problems associated with delay will still be present even with the increased use of high-speed connections. Many of the effects of delay will occur at much lower levels, and cannot be addressed simply by changing the connection speed. Fundamentally, if the designer's goal is to promote a positive attitude, the site delay should be kept below 8 seconds if possible. If the goal is to encourage the user to "stick with" the task or to return later, then the site delay should be kept below 4 seconds.

The effects of increases in delay also appear to depend on the familiarity of terminology used in organizing the site. For familiar sites, performance does not appear to be affected by changes in delay, at least not at the levels tested in this research. This result may not be surprising. When the content is familiar, users are still capable of completing their tasks regardless of the amount of delay they experience. However, increases in delay explain as much as 17% of the variance in user's attitudes and intentions to return to these same familiar sites. For unfamiliar sites, the impacts of changes in delay are also significant, although these changes explain less of the variance. This result suggests that while users are still sensitive to delay, it has less of an effect, possibly because of other difficulties associated from navigating in an unfamiliar environment. These results suggest that as users become more familiar with a Web site, delays become more salient and play a larger role in formulating attitudes and intentions.

MIS researchers quite often focus on behavioral intentions in their research, yet most studies do not provide performance measures in addition to measures of intentions. Intentions can have what one might consider a meaningful basis in reality if they correlate with performance. Our data revealed that, indeed, the correlation between intentions and performance is .436 ($p < .001$; $R^2 = .19$), which does seem to provide some support for the measurement of behavioral intentions. However, given that one of the two variables (presumably performance) explains only 19% of the variation in the other variable (presumably behavioral intentions), there are obviously still other factors at work in the formation of intentions. Future research might address a richer set of antecedents of a user's behavioral intentions.

Several limitations must be mentioned. First, in this research all delays were carried out the same way on each page. While the type of delay used is common and can be seen in non-laboratory situations, it does not represent all possible manners of delay that might actually occur in Internet use. The results, therefore, cannot necessarily be attributed to all types of delays. Future research may explore the effect of different manifestations of delay or variation in these manifestations on performance, attitudes, and intentions. Additionally, this research did not address user expectations or the level of importance that users put on the tasks or information available on the sites. In a laboratory setting it would be difficult to manipulate these factors, however, they could influence users' sensitivity to delays.

Two issues surfaced regarding behavioral intentions. First, intentions to return to a site might be difficult to assess when using artificial sites in a laboratory. However, Hypothesis 2 (relationship between attitudes and behavioral intentions) provides a measure of criterion-related validity, and we worded our questions to ask if students would *want to* return, rather than if they *would* return. The second issue addressed the conceptual and empirical distinction between attitudes and behavioral intentions. It is possible that behavioral intentions are actually *part* of a set of attitudes, especially when considering the tripartite view of attitudes (Hilgard, 1980). More research is needed to determine to what extent attitudes can or should be distinguished from behavioral intentions.

This study attempted to bring together factors previously studied separately. We coupled a variety of delay levels with site familiarity in predicting user attitudes, behavior, and performance, three important outcomes examined in previous research. In bringing these factors together, it appears that users are much more impatient than previously thought. If this impatience is indeed task independent, as some, but not all, previous work suggests, subsequent studies might investigate ways to reduce the impatience or at least reduce any ill effects resulting from that impatience, such as failure to return to a site or the formation of negative attitudes and/or word of mouth.

Future research should focus on identifying and quantifying factors that interact with the tolerance for delay in an attempt to formulate a more complete model for understanding its antecedents and consequences. Those factors could include some that have already been examined, such as feedback (Polak, 2002), variability (Polak, 2002), familiarity (Galletta et al., 2003), and site depth (Galletta et al., 2003), and some that have not, such as expectations, involvement with site content, graphics-intensiveness, database-intensiveness, and processing-intensiveness.

Such understanding will allow researchers to provide experimental environments that are reasonable, would allow researchers and practitioners to more realistically assess Web design alternatives, and would allow practitioners to be more sensitive to the needs of Web users.

References

- Agarwal, R. and Venkatesh, V. (2002). "Assessing a firm's Web presence: A heuristic evaluation procedure for the measurement of usability." *Information Systems Research*, Vol. 13, Iss. 2; pg. 168, 21 pgs

- Ajzen, I. (2001). "Nature and Operation of Attitudes," *Annual Review of Psychology*, 52, 27-58.
- Armitage C.J. & Conner M. (2001). "Efficacy of the theory of planned behavior: a meta-analytic review," *British Journal of Social Psychology*, 40, 471-499.
- Au, N., Ngai, E.W.T. & Cheng, T.C.E. (2002). "A critical review of end-user information system satisfaction research and a new research framework," *OMEGA – International Journal of Management Science*, 30 (6): 451-478 December.
- Bergman, H., Brinkman, A., & Koelega, H.S. (1981). "System response time and problem solving behavior," *Proceedings of the Human Factors Society – 25th Annual Meeting*, 749-753.
- Butler, T.W. (1983) "Computer response time and user performance," *Proceedings of ACM SIGCHI '83 Conference on Human Factors in Computer Systems*, 58-62.
- Carbonell, J.R., Elkind, J.I., & Nickerson, R.S. (1968) "On the psychological importance of time in a time-sharing system," *Human Factors*, 10, 135-142.
- Card, S. K., Moran, T. P., & Newell, A. (1983). *The Psychology of Human-Computer Interaction*. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Chin, J.P., Diehl, V.A. & Norman, K.L. (1988). "Development of an instrument measuring user satisfaction of the human-computer interface," *Proceedings of CHI '88—Human Factors in Computing Systems*, New York, 213-218.
- Dannenbring, G.L. (1984). "The effects of computer response time on user performance and satisfaction: A preliminary investigation," *Behavior Research Methods & Instrumentation*, 15 (2), 213-216.
- Davis, F.D., Bagozzi, R.P., & Warshaw, P.R. (1989). "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science* 35 (8), 982-1003.
- Davis, E.S. & Hantula, D.A. (2001). "The effects of download delay on performance and end-user satisfaction in an Internet tutorial," *Computers in Human Behavior*, 17, 249-268.
- Devaraj, S., Fan, M., & Kohli, R. (2002). "Antecedents of B2C Channel Satisfaction and Preference: Validating e-Commerce Metrics," *Information Systems Research*, 13 (3), 316-333.
- Dickson, G.W., Senn, J.A. and Chervany, N.L. (1977). "Research in Management Information Systems: The Minnesota Experiments," *Management Science*, Vol. 23, No. 9: 913-923.
- Galletta, D.F., Ahuja, M., Hartman, A., Peace, A.G., & Teo, T. (1995). "Social Influence and End-User Training," *Communications of the ACM*, 38 (7), 70-79.
- Galletta, D., Henry, R., McCoy, S., & Polak, P. (2003). "The direct and interactive effects of web site speed, familiarity, and breadth on user attitudes, behavioral intentions, and performance," *Working paper, University of Pittsburgh, Katz Graduate School of Business*.
- Goodman, T.J. & Spence, R. (1978). "The effect of system response time on interactive computer-aided problem solving," presented at *Proc. Siggraph '78 Conf. Association for Computing Machinery*, New York.
- Hilgard, E.R. (1980). "The trilogy of mind: Cognition, affection, and conation," *Journal of the History of the Behavioral Sciences*, 16, 107-117.
- Hill, T., Smith, N., and Mann, M. (1987). "Role of Efficacy Expectations in Predicting the Decision to Use Advanced Technologies: A Case of Computers," *Journal of Applied Psychology*, (72: 2), 1987, pp. 307-318.
- Hoxmeier, J.A. & DiCesare, C. (2000). "System response time and user satisfaction: An experimental study of browser-based applications," *Proceedings of the Association of Information Systems Americas Conference*, Long Beach, California.

- IBM (2003). "Final Testing." International Business Machines, http://www-3.ibm.com/ibm/easy/eou_ext.nsf/Publish/609
- Jacko, J.A., Sears, A. & Borella, M.S. (2000). "The effect of network delay and media on user perceptions of web resources," *Behaviour and Information Technology*, 19 (6), 427-439.
- Keeker, K. (1997). "Improving Web-Site Usability and Appeal: Guidelines Compiled by MSN Usability Research," <http://msdn.microsoft.com/library/default.asp?url=/library/en-us/dnsiteplan/html/improvingwebsiteusa.asp>
- Kim, M.S. & Hunter, J.E. (1993). "Relationships among Attitudes, Behavioral Intentions, and Behaviors: A Meta-analysis of Past Research," *Communication Research*, 20, 331-364.
- Koufaris, M. (2002). "Applying the Technology Acceptance Model and Flow Theory to Online Consumer Behavior," *Information Systems Research*, 13 (2), 205-223.
- Kuhmann, W. (1989). "Experimental investigation of stress-inducing properties of system response times," *Ergonomics*, 32 (3), 271-280.
- Liebelt, L.S., McDonald, J.E., Stone, J.D. & Karat, J. (1982). "The Effect of Organization on Learning Menu Access," *Proceedings of the Human Factors Society, 26th Annual Meeting*, Santa Monica, CA, 546-550.
- Lightner, N.J. & Bose, I. (1996). "What is wrong with the world-wide web?: A diagnosis of some problems and prescription of some remedies," *Ergonomics*, 39 (8), 995-1004.
- McDonald, J.E., Stone, J.D., & Liebelt, L.S. (1983). "Searching for Items in Menus: The Effects of Organization and Type of Target," *Proceedings of the Human Factors Society, 27th Annual Meeting*, Santa Monica, CA, 834-837.
- McKinney, V., Yoon, K. & Zahedi, F. (2002). "The Measurement of Web-Customer Satisfaction: An Expectation and Disconfirmation Approach," *Information Systems Research*, 13 (3), 296-315.
- Miller, R.B. (1968). "Response time in man-computer conversational transactions," *Proceedings of the Fall Joint Computer Conference*, 267-277.
- Nah, F.H. (2002). "A Study of Web Users' Waiting Time," in *Intelligent Support Systems Technology: Knowledge Management*, Vijayan Sugumaran (editor), IRM Press, 145-152.
- Nah, F.H. (2003). "A Study on Tolerable Waiting Time: How Long Are Web Users Willing To Wait?" *Proceedings of the 9th Americas Conference on Information Systems*, Tampa, Florida, 2212-2222.
- Newell, A. & Card, S. (1985). "The Prospects for Psychological Science in Human-Computer Interaction," *Human-Computer Interaction*, 1, 209-242.
- Newman, J.R. (1966). "Extension of human capability through information processing and display systems," System Development Corp., Santa Monica, California.
- Nielsen, J. (1997) "The Need for Speed," <http://www.useit.com/alertbox/9703a.html>
- Nielsen, J. (1999a). "User interface directions for the web," *Communications of the ACM*, 42 (1), 65-72.
- Nielsen, J. (1999b). "'Top ten mistakes' revisited three years later," *Alertbox*, <http://www.useit.com/alertbox/990502.html>
- Nielsen, J. (1999c). "Who commits the 'Top ten mistakes' of web design?" *Alertbox*, <http://www.useit.com/alertbox/990516.html>
- Nielsen, J. (1999d). "The Top ten new mistakes of web design," *Alertbox*, <http://www.useit.com/alertbox/990530.html>
- NIST (2003). National Institute of Standards and Technology, WebSAT Evaluation Rules, http://zing.ncsl.nist.gov/WebTools/WebSAT/websat_rules.html

- Norman, K.L. & Chin, J.P. (1988). "The Menu Metaphor: Food for Thought," *Behavior and Information Technology*, 8 (2), 125-134.
- Nunnally, J. (1978). *Psychometric Theory*, New York: McGraw-Hill Book Company.
- Oliver R.L. & Swan J.E. (1989). "Consumer perceptions of interpersonal equity and satisfaction in transactions: a field survey approach," *Journal of Marketing*, 53, 21-35.
- Palmer, J. (2002). "Web Site Usability, Design, and Performance Metrics," *Information Systems Research*, 13 (2), 155-167.
- Polak, P. (2002). "The direct and interactive effects of web site delay length, delay variability, and feedback on user attitudes, performance, and intentions," *unpublished doctoral dissertation, University of Pittsburgh, Katz Graduate School of Business*.
- Ramsay, J., Barbesi, A. & Preece, J. (1998). "A psychological investigation of long retrieval times on the world wide web," *Interacting with Computers*, 10, 77-86.
- Ranganathan, C. & Ganapathy, S. (2002). "Key dimensions of business-to-consumer web sites," *Information and Management*, 39 (6), 457-465.
- Robertson, G., McCracken, D., & Newell, A. (1981) "The ZOG Approach to Man-Machine Communication," *International Journal of Man-Machine Studies*, 14, 461-488.
- Rose, G.M. (2000). "The effect of download time on e-commerce: The download time brand impact model," *unpublished doctoral thesis, Georgia State University*.
- Rose, G.M., Khoo, H. & Straub, D. (1999). "Current Technological Impediments to Business-to-Business Electronic Commerce," *Communications of the AIS*, 1 (16), 1-74.
- Rose, G.M, Lees, J. & Meuter, M. (2001). "A refined view of download time impacts on e-consumer attitudes and patronage intentions toward e-retailers," *The International Journal on Media Management*, 3 (2), 105-111.
- Rose, G.M. & Straub, D. (2001). "The Effect of Download Time on Consumer Attitude Toward the E-Service Retailer," *e-Service Journal*, 1 (1), 55-76.
- Sackman, H. (1967). "Experimental investigation of user performance in time-shared computing systems," System Development Corp., Santa Monica, California.
- Searchenginewatch (2002). "The technology behind Google," *SearchDay*, August 12, 2002, available at <http://searchenginewatch.com/searchday/02/sd0812-googletech.html>.
- Sears, A. & Jacko, J.A. (2000). "Understanding the relation between network quality of service and the usability of distributed multimedia documents," *Human-Computer Interaction*, 15 (1), 43-68.
- Shneiderman, B. (1998). *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, 3rd edition, Reading, Massachusetts: Addison-Wesley.
- Sheppard, B.H., Hartwick, J., & Warshaw, P.R. (1988). "The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research," *Journal of Consumer Research*, 15, 325-343.
- Simon, H.A. (1966). "Reflections on time sharing from a user's point of view," *Computer Science Research Review*, 43-51, Carnegie Institute of Technology.
- Simon, H.A. (1990). "Invariants of human behavior," *Annual Review of Psychology*, 41, 1-19.
- Straub, D.W., Hoffman, D.J., Weber, B.W., & Steinfield, C. (2002). "Measuring e-Commerce in Net-Enabled Organizations: An Introduction to the Special Issue," *Information Systems Research*, 13 (2), 115-124.
- Thadhani, A.J. (1981). "Interactive user productivity," *IBM Systems Journal*, 20 (4), 407-423.
- Torkzadeh, G. & Dhillon, G. (2002). "Measuring Factors that Influence the Success of Internet Commerce," *Information Systems Research*, 13 (2), 187-204.

- Turban, E. & Gehrke, D. (2000). "Determinants of E-Commerce Web Sites," *Human Systems Management*, 19, 111-120.
- Venkatesh, V., Morris, M.G., Davis, G.B., & Davis, F.D. (2003). "User Acceptance of Information Technology: Toward a Unified View," *MIS Quarterly*, 27 (3), 425-478.
- Voich, D. (1995). *Comparative Empirical Analysis of Cultural Values and Perceptions of Political Economy Issues*, Westport, Connecticut: Praeger.
- Weinberg, B.D. (2000). "Don't keep your internet customers waiting too long at the (virtual) front door," *Journal of Interactive Marketing*, 14 (1), 30-39.
- Wickelgren, W.A. (1977). "Speed-Accuracy Tradeoff and Information Processing Dynamics," *Acta Psychologica*, 41, 67-85.
- Yntema, D.B. (1968). "Engineering psychology in man-computer interaction," paper presented at *Annual Convention of the American Psychological Association*, San Francisco, California.
- Zona Research Study (1999). "The need for speed," <http://www.zonaresearch.com/info/press/99%2Djun30.htm>

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Appendix

Measures Used in this Study

Performance Measures – Familiar Site

Pete's General Store

Please answer each of the following 9 questions in turn, without jumping back and forth among them. If you cannot find the answer to any particular question, please skip it and move on. Speed will be a factor in evaluating your performance.

1. How much is the "Ice Box Cleaner TM Dust Brush?"
2. How much is the "Professional Pedicure Tool?"
3. "Gummi Bears" are now available in what new flavor at our store?
4. Who recommends "Bertolli Olive Oil" for healthy cooking?
5. How much would it cost, in total, to purchase a 5-pack of "Contact Lens Suction Cups" and a 10-pack of "Contact Lens Storage Cases?"
6. "Lay's Wow Low-Fat Chips" are available in what size bags?
7. What is the difference in price between the 32-oz bottle of "Shower Clean TM" and the 24-oz bottle of "Shower Tile Cleaner?"
8. In what size bottle do we carry "Listerine Germ Killer?"
9. What is the advantage of our "Ice Cube Trays" over normal ones?

Performance Measures – Unfamiliar Site

A.C.T. Systems

Please answer each of the following 9 questions in turn, without jumping back and forth among them. If you cannot find the answer to any particular question, please skip it and move on. Speed will be a factor in evaluating your performance.

1. What function does "DataBridge" perform? It connects _____ in your _____
2. Which magazine rated our "Microphones" the best on the market?
3. On what formats can you purchase "Trim-It 4.1?"
4. Under which operating systems does "Markit" work best?
5. What is the difference in price between "Organizer" and "Re-Organizer Pro?"
6. How much is "Structure Checker 2?"
7. "Set Saver" is said to work "great" with "Outlier Out!" How much would it cost to purchase both?
8. With what software package does "Errorchek" work?
9. Who says that "Data Relationship +" works better than other software on the market today?

Behavioral Intentions items

	Extremely Low/Little/Few					Extremely High/Many	
1. How readily would you recommend that others visit this site?	1	2	3	4	5	6	7
2. How likely is it that you would want to visit this site again?	1	2	3	4	5	6	7

Attitude items*Overall Reactions to the Site*

1. terrible	1	2	3	4	5	6	7	8	9	wonderful
2. frustrating	1	2	3	4	5	6	7	8	9	satisfying
3. dull	1	2	3	4	5	6	7	8	9	stimulating
4. difficult	1	2	3	4	5	6	7	8	9	easy
5. inadequate design	1	2	3	4	5	6	7	8	9	adequate design
6. rigid	1	2	3	4	5	6	7	8	9	flexible
7. difficult to explore	1	2	3	4	5	6	7	8	9	easy to explore

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